CHAPTER 26
Meninges

KEY TEACHING POINTS

- There are three meningeal signs: neck stiffness, Kernig sign, and Brudzinski sign. Each of these signs reflects the patient's natural rejection of any movement that stretches the spinal nerves passing through a spinal subarachnoid space irritated by inflammation, hemorrhage, or tumor.
- In studies of subarachnoid hemorrhage, neck stiffness has been defined as inability to either touch the chin to the chest or lift the head 8 cm off the bed when supine.
- Neck stiffness is found in 84% of patients with bacterial meningitis.
- In patients presenting to emergency departments with either acute atraumatic headache or stroke, the finding of neck stiffness markedly increases the probability of intracranial hemorrhage.

I. THE FINDINGS

The terms *meningeal signs* and *meningismus* refer to the physical findings that develop after meningeal irritation from inflammation, tumor, or hemorrhage. Those most widely known are neck stiffness (or *nuchal rigidity*), Kernig sign, and Brudzinski sign.

A. NECK STIFFNESS

Neck stiffness denotes involuntary resistance to neck flexion, which the clinician perceives when trying to bend the patient's neck, bringing the chin down to the chest. One specific definition of *neck stiffness* (from studies of patients with subarachnoid hemorrhage) is the inability to either touch the chin to the chest or lift the head 8 cm off the bed when supine.[1] Occasionally the aggravated extensor tone of the neck and spine is so severe that the patient's entire spine is hyperextended, leaving the torso of the supine patient supported by only occiput and heels, an extreme posture called **opisthotonus**.

B. KERNIG SIGN

The Kernig sign was first described by Vladimir Kernig in 1882. With the patient's hip and knee flexed, Kernig sign is positive when the patient resists extension of the knee. Kernig called this a "contracture" of the hamstrings because the knee would not extend beyond 135 degrees (with hip flexed), even though the knee extended fully if the hip was first positioned in the fully extended position (Fig. 26.1).[2] Most clinicians perform this test in the supine patient, although Kernig described the test being performed in the seated patient.

C. BRUDZINSKI SIGN

Jozef Brudzinski described several meningeal signs between 1909 and 1916. In his most popular sign, flexion of the supine patient's neck causes the patient to flex both hips and knees, thus retracting the legs toward the chest (see Fig. 26.1).[2]

II. PATHOGENESIS OF MENINGEAL SIGNS

The basis for all meningeal signs is the patient's natural rejection of any movement that stretches spinal nerves, all of which pass through the irritated subarachnoid space. Experiments with cadavers show that flexion of the neck pulls the spinal cord toward the head, thus stretching spinal nerves, whereas flexion of the hips with knees extended pulls on the sciatic nerve, thus displacing the conus of the spinal cord downward toward the sacrum.[3] In contrast, flexion of the hips with knees flexed does not stretch the sciatic nerve.

These experiments explain why patients with meningeal irritation have neck stiffness and a positive Kernig sign, and they also show that Kernig sign does not differ from the straight leg-raising test for sciatica (see Chapter 64). However, Brudzinski sign is more difficult to understand. At first, it seems logical that patients with meningeal irritation would want to extend their hips and flex their knees when their neck is flexed. Although this position removes tension from the sciatic

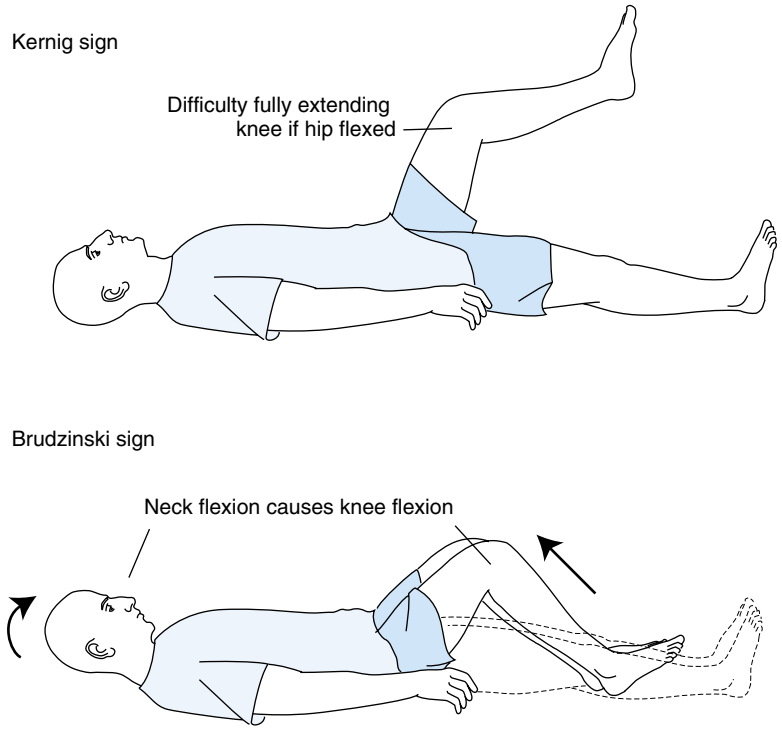

FIG. 26.1 KERNIG SIGN AND BRUDZINSKI SIGN. In Kernig sign (*top*) the patient resists full extension of the knee when the knee and hip are first flexed (patient's left leg), although the knee extends normally if the hip is extended (patient's right leg). In Brudzinski sign (*bottom*) flexion of the patient's neck causes the hips and knees to flex, pulling both legs up toward the chest (see the text).

nerve, it stretches the femoral nerve,[3] explaining why Brudzinski test causes the patient to flex both hips and knees, thus relieving tension on both nerves.

III. CLINICAL SIGNIFICANCE

A. ACUTE BACTERIAL MENINGITIS

Table 26.1 summarizes the frequency of individual findings of almost 1500 adults with acute bacterial meningitis (principally from *Streptococcus pneumoniae, Neisseria meningiditis, and Listeria monocytogenes;* cases of tuberculosis were excluded). This table reveals that the most frequent findings in bacterial meningitis are neck stiffness, fever, and altered mental status. Neck stiffness is a more frequent sign than Kernig or Brudzinski sign (sensitivity is 84% for neck stiffness vs. 61% for Kernig or Brudzinski sign), although this difference is not significant and may reflect in part the clinician's diligence in looking for these findings. Of the patients with petechial rash, 72% to 92% have infection with *N. meningiditis*.[7,13]

Some of the heterogeneity in these studies (see Table 26.1) is due to the ages of the patients. Compared with younger patients, elderly patients (defined as >65 years old in three of four studies, >50 years in one study) have a higher frequency of mental status change (90% vs. 72%), focal neurologic signs (30% vs. 17%), and fever (94% vs. 84%) but no difference in the frequency of neck stiffness.[6,9,18,19]

Few studies have addressed the overall accuracy of meningeal signs. In three studies of more than 700 patients undergoing lumbar puncture because of suspected meningitis, Kernig sign (likelihood ratio [LR] = 2.5, EBM Box 26.1), Brudzinski sign (LR

TABLE 26.1 Acute Bacterial Meningitis and Subarachnoid Hemorrhage*

Finding	Frequency (%)†
ACUTE BACTERIAL MENINGITIS	
Neck stiffness	84
Fever	66-97
Altered mental status	55-95
Kernig or Brudzinski sign	61
Focal neurologic signs	9-37
Seizures	5-28
Petechial rash	3-52
SUBARACHNOID HEMORRHAGE	
Neck stiffness	21-86
Seizures	7-32
Altered mental status	29-64
Focal neurologic findings	10-36
Fever	6
Preretinal hemorrhages	4

*Data obtained from almost 1500 patients with meningitis based upon references 4-13 and 692 patients with subarachnoid hemorrhage based upon references 14-17.
†Results are overall mean frequency or, if statistically heterogeneous, the range of values. Diagnostic standard: For *meningitis*, cerebrospinal fluid pleocytosis and microbiologic or postmortem data supporting bacterial meningitis; for *subarachnoid hemorrhage*, computed tomography or lumbar puncture.

= 2.2), and neck stiffness (LR = 1.5) increased slightly the probability of meningitis (i.e., cerebrospinal fluid white blood cell count [CSF WBC] ≥ 100/mL). Surprisingly, the sensitivity of findings in these studies (e.g., only 20% to 52% for neck stiffness) is much lower than observed in observational studies of meningitis (84%; see Table 26.1), but very few patients with meningitis in the studies reviewed in EBM Box 26.1 actually had acute bacterial meningitis (most had aseptic meningitis).[20-22] Other studies have addressed the specificity of meningeal signs: in one such study, nuchal rigidity was found in 35% of hospitalized elderly patients (mean age 79 years), none of whom had meningitis, (i.e., specificity = 65%).[23] In addition, the Kernig sign may appear in patients with sciatica and those with subarachnoid or epidural hemorrhage or tumor of the cauda equina.[24]

When present, Kernig sign should be symmetric. In one study of 51 consecutive comatose patients with Kernig sign, asymmetry of the sign indicated that the patient would have hemiparesis after awakening, the side with the less prominent Kernig sign indicating the side with paresis.[25]

B. SUBARACHNOID HEMORRHAGE AND INTRACEREBRAL HEMORRHAGE

Table 26.1 summarizes the findings of almost 700 patients with subarachnoid hemorrhage, 70% to 95% of whom presented with a severe precipitous headache. The most common physical finding in these patients was neck stiffness (sensitivity, 21%

EBM BOX 26.1
*Meningitis**

Finding (Reference)	*Sensitivity (%)*	*Specificity (%)*	*Likelihood Ratio† if Finding Is*	
			Present	*Absent*
Neck stiffness[20-22]	20-52	69-81	1.5	NS
Kernig sign[20-22]	7-18	93-98	2.5	NS
Brudzinski sign[20-22]	7-14	94-98	2.2	NS

*Diagnostic standard: for *meningitis,* cerebrospinal fluid pleocytosis ≥100 white blood cells per microliter.
†Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
NS, Not significant.
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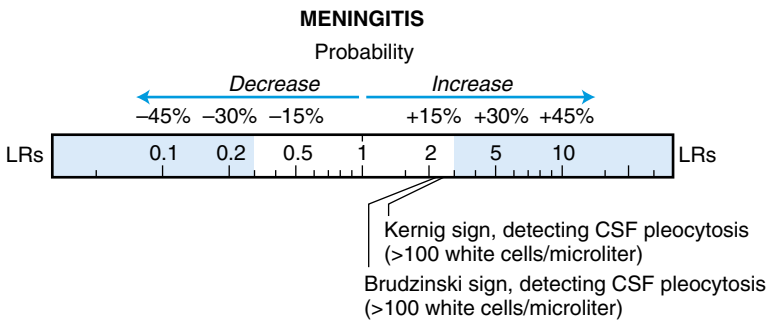
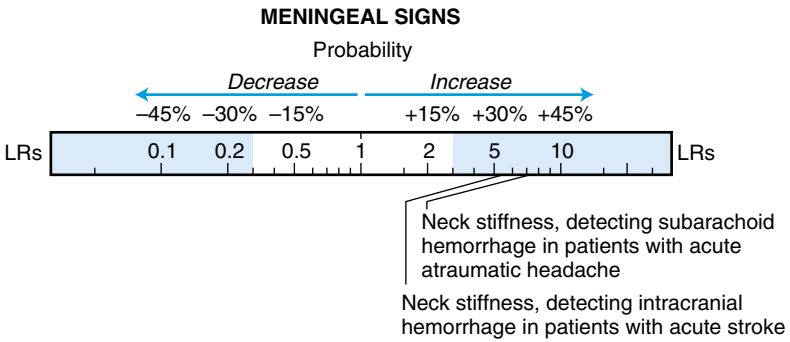


EBM BOX 26.2
*Intracranial Hemorrhage**

Finding (Reference)†	*Sensitivity (%)*	*Specificity (%)*	Likelihood Ratio‡ if Finding Is *Present*	Likelihood Ratio‡ if Finding Is *Absent*
Neck stiffness, detecting subarachnoid hemorrhage in patients with sudden atraumatic headache[1,26]	28-31	95-97	**7.1**	0.7
Neck stiffness, detecting intracranial hemorrhage in patients with stroke[27-32]	16-48	81-98	**5.4**	0.7

*Diagnostic standard: for *intracranial hemorrhage,* neuroimaging; for *subarachnoid hemorrhage*, neuroimaging, lumbar puncture, or both.
†Definition of findings: for *neck stiffness,* undefined or inability to touch chin to sternum or lift the head 8 cm.
‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
NS, Not significant.
Click here to access calculator



to 86%). In studies of more than 4000 patients presenting to emergency departments with acute atraumatic severe headache, the finding of neck stiffness significantly increased the probability of subarachnoid hemorrhage (LR = 7.1; EBM Box 26.2).

Significant intracerebral hemorrhage may also produce subarachnoid bleeding and neck stiffness (i.e., intraventricular blood may pass through the median and lateral apertures of the fourth ventricle into the subarachnoid space at the base of the brain). In studies of almost 1000 patients presenting to emergency departments with stroke (i.e., acute neurologic deficits believed to be vascular in origin), the finding of neck stiffness increases the probability of intracranial blood, either subarachnoid or intracerebral hemorrhage (LR = 5.4). Subarachnoid hemorrhage is more likely in these patients if there are no focal findings (sensitivity = 64%, specificity = 89%, positive LR = 5.9).[16]

The references for this chapter can be found on www.expertconsult.com.

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